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PATENT AND TECHNICAL TRANSLATION

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DECLARATION

The undersigned, Olaf Bexhoeft, hereby states that he is well acquainted with both the English and German languages and that the attached is a true translation to the best of his knowledge and ability of the German text of PCT/EP2003/012855, filed on 11/17/2003, and published on 06/03/2004 under No. WO 2004/045712 A1.

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

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DEFIBRILLATOR COMPRISING A RELAY TESTING DEVICE

The invention relates to a defibrillator, in particular a portable external defibrillator, having an output stage, which has a high-voltage element and patient electrode connectors, which can be automatically connected with the latter by means of a coupling circuit via a relay, as well as a relay testing device.

Such a defibrillator is disclosed in EP 0 946 956 B1. A method is provided by this known defibrillator, by means of which a relay, which is arranged in a coupling circuit between a high-voltage element and patient electrodes, is tested and which can be brought on the one hand into an open position, and on the other hand into a closed position, in which the patient electrodes are connected with the high- voltage element. A test run is performed for testing the relay, in which a discharge of an energy storage element in the form of a capacitor, which stores the energy for the defibrillation pulse, is performed via the relay and the patient electrodes, and the voltage at the capacitor is measured. The voltage at the capacitor during the discharge is compared with a threshold voltage in order to draw conclusions regarding the relay status. In various situations it is difficult to arrive at a dependable statement regarding the relay status in this way.

An automatic external defibrillator (AED), in particular a portable one, with a specially embodied high-

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voltage element with an H-bridge and patient electrodes, which are connected in the transverse branch of the latter in series to form an inductive resistor (coil or equivalent component) is recited in DE 100 65 104 A1. It is advantageously possible with this known defibrillator to generate bi-phased defibrillation pulses by an appropriate control of switching members of the H-bridge. No relay test is mentioned there.

The object of the invention is based on making available an external defibrillator, in particular a portable one, of the type mentioned at the outset, by means of which the testing of the coupling circuit can be performed as dependably as possible.

This object is attained by means of the characteristics of claim 1. In accordance therewith it is provided that a discharge resistor arrangement exists, to which a switch can be automatically made by means of the relay, instead of to the patient electrode connectors, and that the relay testing device is designed for testing the relay while incorporating the status of the connected discharge resistor arrangement.

Dependable conditions for testing the relay are created by means of the connected discharge resistor arrangement, so that a dependable evaluation of the relay status is achieved.

The dependable testing of the coupling relay is furthered in that the relay testing device has its own voltage supply for a test supply voltage, by means of which a current can be run through the relay for testing the relay with the connected discharge resistor arrangement, wherein a current from the high-voltage element is blocked. These steps contribute to unequivocal testing conditions, while a simple construction of the measuring device can be realized.

A further advantageous embodiment of the relay testing device consists in that it has a measuring branch in which, with the discharge resistor arrangement connected on the one hand, and the discharge resistor arrangement disconnected on the other hand, different voltages or measuring currents exist, which can be incorporated in the testing of the relay.

In this case a dependable measurement is aided in that the measuring branch has a measurement amplification circuit for forming a measured value regarding a relay status.

Unequivocal statements are furthermore aided in that the measurement amplification circuit has a comparator for making a comparison with a reference variable.

An advantageous construction of the defibrillator with the relay testing device moreover consists in that the high- voltage element has an H-bridge, which can be charged with high voltage by an energy storage device for a defibrillation pulse, and has controllable switching members in the H-legs, and that the relay is arranged in series with an inductive resistor and on one side with the discharge resistor or, on the other side, with the patient electrodes connected to the patient electrode connectors in the transverse branch of the H-bridge.

A further advantageous embodiment of the defibrillator with the relay testing device consists in that a further relay is integrated between the relay and the patient electrode connectors, by means of which the patient electrodes can be selectively connected with the high-voltage element or an EKG measuring device.

The invention will be explained in greater detail in what follows by means of an exemplary embodiment and by making reference to the drawing.

The drawing figure shows an output stage of a defibrillator, in particular a portable external automatic defibrillator (AED), having a high-voltage element with a charging device 1 and an H-bridge 2, as well as a coupling circuit 3 connected therewith. The charging device has a charging element 1.1, for example an alternating voltage source with a transformer 1.2 connected therewith, for generating a high voltage, by means of which an energy storage element in the form of a storage capacitor C, or a storage capacitor arrangement, is charged for defibrillation with electrical energy via a charge diode 1.3 in a manner known per se. In its H-legs, respectively oriented toward the positive pole on the one side and toward the negative pole on the other side, the H-bridge 2 has respective switching members 2.1, 2.2, 2.3, 2.4, which are triggered by means of assigned trigger circuits 2.5, 2.6, 2.7, 2.8, such as described in greater detail in DE 100 65 104 A1 mentioned at the outset, for example. As a special feature of the instant H-bridge, a diode arrangement 2.9, 2.10 is arranged anti-parallel in respect to two switching members 2,3, 2.4, one of which is arranged in the H-leg leading to the positive pole and one in the oppositely located H-leg leading to the negative pole, in order to assure the dependable functioning of the switching members 2.1, 2.2, 2.3, 2.4 during bi-phased operation by means of free-wheeling, in particular if switching processes at a higher frequency, for example 10 kHz or more, are performed for regulating the pulse energy, for example by means of a current control. In the transverse branch QZ of the H-bridge 2, an inductive resistor L1 in the form of a coil or of an equivalent switching element lies in series with a coupling relay 3.1 of the coupling circuit 3, as well as in series with a discharge resistor RD or, selectively instead of the latter, with patient electrode connectors PEA, which can be automatically connected by means of the relay and to which patient electrodes PE are connected during the operation. The discharge resistor

RD is, for example, a resistor comparable with the patient impedance of a defined value, for example in the range between 10 and 100 Ohm, for example 25 or 50 Ohm. For assuring a defined state, the energy storage element C can be discharged via the discharge resistor after a time of non-use which can be fixed, or after a defibrillation.

Besides the relay 3.1, the coupling circuit 3 has a further relay 3.2 located between the first one and the patient electrode connectors PEA, by means of which the patient electrodes PE can be selectively connected with an EKG measuring device EKG or the H-bridge 2 of the high- voltage element. Both relays 3.1, 3.2 can be triggered by means of respectively assigned relay controls 3.3, 3.4, wherein in the exemplary embodiment represented, the relay control 3.3 has control circuit resistors R4, R5, a control circuit transistor T1, as well as a control circuit diode D4 in the arrangement represented. The further relay control 3.4 has control circuit resistors R6, R7, R8, two control circuit transistors T2, T3, as well as a control circuit diode in the arrangement represented.

The two relays 3.1, 3.2 can be switched between the indicated switching positions by means of the relay controls 3.3, 3.4, which could also be designed in a different way.

The coupling circuit 3 is furthermore equipped with a relay testing device for the coupling relay 3.1. The relay testing device is used for checking the relay 3.1, wherein the current is cut off from the high-voltage element, in this case the H-bridge 2, by the appropriate triggering of the switching members 2.1, 2.2, 2.3, 2.4. In place of this, a test supply voltage UT, separately provided for the relay test, on an order of magnitude of some, or some 10 Volt, for example between 6 and 30 Volt, is made available by a test supply voltage device. The relay testing device is designed in such a way that, with the discharge

resistor RD connected to the relay 3.1, a closed electrical circuit is formed from the positive pole of the test supply voltage UT via a first resistor arrangement RI with several resistors, the discharge resistors RD, the corresponding contacts of the relay 3.1 and a further resistor arrangement RII with several resistors, to ground GND. Parallel with this current path, a measuring branch ME with measuring circuit resistors R1, R2, R3 and measuring circuit diodes D1, D2, D3 and a comparator circuit K is formed between the positive pole of the test supply voltage UT and the first resistor arrangement RI, wherein the measuring circuit resistor R1 is located in a current path leading to an input connector of the comparator circuit K, the measuring circuit resistor R2 is connected to ground between the first measuring circuit resistor R2 and the input connector of the comparator circuit K, and the third measuring circuit resistor R at the output of the comparator circuit K is connected with a preselected potential. The measuring circuit diodes D1, D2 are embodied as stabilizing Zener diodes and are connected to ground upstream of the first measuring circuit resistor R1, while the third measuring circuit diode D3 is connected to ground parallel with the second measuring circuit resistor R2. A preselected or preselectable comparison voltage is connected to the second input connector of the comparator circuit K.

If the discharge resistor RD with the relay 3.1 is connected to the respective current path, a partial current l4 of a total current l1 present from the positive pole of the test supply voltage UT to the branching point ME, flows through the relay 3.1, while a further partial current flows to ground as the measuring current l3 through the measuring branch ME via the second measuring circuit resistor R2 and generates a corresponding voltage drop at the latter which, in the connected state of the relay 3.1 results in a comparative voltage corresponding to this state.

If, by means of an appropriate triggering of the relay 3.1, the discharge resistor RD is not connected, the total current I1 flows as the measuring current I2 through the measuring branch ME and generates a correspondingly greater voltage drop at the second measuring circuit resistor R2, which can be detected by means of the comparator circuit K. It is thus possible by means of the measuring branch ME to differentiate between a connected and a non-connected status of the discharge resistor RD, and conclusions can be drawn in this way regarding the proper functioning of the relay 3.1, for which purpose the output signal of the comparator circuit K is suitably evaluated in an evaluating circuit.

Other amplification circuits are conceivable in the measuring branch ME wherein, for example, it is possible to differentiate between not completely closed and completely open states of the relay 3.1, provided such an evaluation is desired. Because of the separate test supply voltage UT, the relay testing device is independent of the high-voltage element, so that a dependable statement regarding the ability of the relay to function is possible. The control circuit of the defibrillator has been designed in such a way that it connects the high-voltage element with the patient electrodes PE only if the relay 3.1 functions correctly. For example, this function can also be realized in that the further relay 3.2 is triggered in such a way that it interrupts the connection between the patient electrodes PE, or the patient electrode connectors PEA, and the high-voltage element if a faulty state of the coupling relay 3.1 is detected. The evaluation can take place in a suitable logic circuit, for example a programmed micro-controller, or another programmable logic unit (CPLD), and can be used for further control functions.